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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Thomas Andrew Strasser et al.

Serial No.: 10/099,888

Filed: 03/15/02

Title: METHOD AND APPARATUS FOR TRANSFERRING WDM SIGNALS BETWEEN DIFFERENT WAVELENGTH DIVISION MULTIPLEXED OPTICAL COMMUNICATIONS SYSTEMS IN AN OPTICALLY TRANSPARENT MANNER

Art Unit: 2633

Examiner: Unassigned

Docket No.: PH01-00-04E

Assistant Commissioner for Patents
Box Missing Parts
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Sir:

In regard to the above-identified application, please enter the following preliminary amendment and remarks:

IN THE SPECIFICATION

Please amend the specification as follows:

Please replace paragraphs **0018, 0019, 0020, 0021, and 0026** with the following rewritten paragraphs:

[0018] Various examples of all-optical reconfigurable optical switches are disclosed in U.S. Patent Application Serial No. 09/571,833, which is hereby incorporated by reference in its entirety, and in particular FIGS. 2-4 of that reference. The switching elements disclosed therein can selectively direct any wavelength component from any input port to any output port, independent of the routing of the other wavelengths without the need for any electrical-to-optical conversion. Another all-optical reconfigurable optical switch that provides additional functionality is disclosed in U.S. Patent Application Serial No. 09/691,812, which is hereby incorporated by reference in its entirety. This reference discloses an optical switching element in which each and every wavelength component can be directed from any given port to any other port without constraint. More specifically, unlike most optical switches, this switch is not limited to providing connections between a subset of input ports and a subset of output ports, or vice versa. Rather, this switch can also provide a connection between two ports within the same subset (either input or output). While the present invention may employ any of the aforementioned reconfigurable optical switches, the optical switch disclosed in U.S. Patent Application Serial No. 09/691,812 will serve as an exemplary reconfigurable optical switch, and accordingly, additional details concerning this switch will be presented below.

[0019] In FIG. 7, the reconfigurable optical switch 800 comprises an optically transparent substrate 808, a plurality of dielectric thin film filters 801, 802, 803, and 804, a plurality of collimating lens pairs 821, 822, 823, and 824, a plurality of tiltable mirrors 815, 816, 817, and 818 and a plurality of output ports 840_1, 840_2, … 840_n. A first filter array is composed of thin film filters 801 and 803 and a second filter array is composed of thin film filters 802 and 804. Individual ones of the collimating lens pairs 821-824 and tiltable mirrors 815-818 are associated with each of the thin film filters. Each thin film filter, along with its associated collimating lens pair and tiltable mirror effectively forms a narrow band, free space switch, i.e. a switch that routes individual channels or wavelength components along different paths. The tiltable mirrors are micro mirrors such as the MEMS (microelectromechanical systems) mirrors.

Alternatively, other mechanisms may be employed to control the position of the mirrors, such as piezoelectric actuators, for example.

[0020] In operation, a WDM optical signal composed of different wavelengths λ_1, λ_2, λ_3 and λ_4 is directed from the optical input port 812 to a collimator lens 814. The WDM signal traverses substrate 808 and is received by thin film filter 801. According to the characteristics of the thin film filter 801, the optical component with wavelength λ_1 is transmitted through the thin film filter 801, while the other wavelength components are reflected and directed to thin film filter 802 via substrate 808. The wavelength component λ_1, which is transmitted through the thin film filter 801, is converged by the collimating lens 821 onto the tiltable mirror 815. Tiltable mirror 815 is positioned so that wavelength component λ_1 is reflected from the mirror to a selected one of the output ports 840_1-840_n via thin film filters 802-804, which all reflect wavelength component λ_1. The particular output port that is selected to receive the wavelength component will determine the particular orientation of the mirror 815.

[0021] As mentioned, the remaining wavelength components λ_2, λ_3, and λ_4 are reflected by thin film filter 801 through lens 821 back into substrate 808 and directed to thin film filter 802. Wavelength component λ_2 is transmitted through thin film filter 802 and lens 822 and directed to a selected output port by tiltable mirror 816 via thin film filters 803-804, which all reflect wavelength component λ_2. Similarly, all other wavelength components are separated in sequence by the thin film filters 803-804 and subsequently directed by tiltable mirrors 817-818 to selected output ports. By appropriate actuation of the tiltable mirrors, each wavelength component can be directed to an output port that is selected independently of all other wavelength components.

[0026] An arrangement of reconfigurable optical switches such as depicted in FIG. 4 is employed in copending U.S. Patent Appl. Serial No. 10/099,890 to provide a protection scheme in the event of a transponder (i.e., a transmitter/receiver pair in which an optical signal originates as, or terminates in, an electrical signal) failure. This arrangement is shown in FIG. 5, which employs four switches 514, 516, 518 and 520. In comparing FIGS. 4 and 5 it should be noted while FIG. 4 only depicts a single fiber path 710 transmitting in one direction, in FIG.5 two

fibers paths 530 and 540 are shown to support bi-directional communication (i.e., fiber path 710 in FIG. 4 corresponds to either of the fiber paths 530 and 540 in FIG. 5). In the configuration of FIG. 5 service can be maintained even if there is a failure in one of the switches. The transponders are arranged in transponder pairs 522-527 located in adjacent slots. The individual transponders in each pair can serve as backup for the other in case of a failure. The transponders in each pair communicate with different switches. For example, in pair 522, transponder 522_1 receives and transmits via switches 514 and 516, respectively, while transponder 522_2 receives and transmits via switches 520 and 518, respectively. Since the two transponders in each pair transmit and receive on completely different switches, a failure in one switch need not disrupt service because the service provided by the impacted switch can be provided by the other transponder in the adjacent slot. A comparison of FIGS. 4 and 5 suggests that any one or more of the transponder pairs 522-527 in FIG. 5 may be replaced with a subtending ring such as rings 712 and 714 in FIG. 4.

STATUS OF CLAIMS

Claims 1-4 are pending.

REMARKS

This is a preliminary amendment before the first Office Action.

Claims 1-4 are pending herein.

The specification is amended to include the previously unknown serial numbers and filing dates of three related co-pending patent applications, and to correct inadvertent typographical errors made in certain reference numbers so that these reference numbers correctly correspond to the reference numbers used in the drawings.

Attached hereto is a marked-up version of the changes made to the specification by this preliminary amendment. The attached page is captioned **"Version with markings to show changes made"**.

CONCLUSION

Applicant submits Claims 1-4 are in condition for examination, early notification of which is earnestly solicited. Should the Examiner be of the view that an interview would expedite consideration of this Amendment or of the application at large, request is made that the Examiner telephone the Applicant's attorney at (908) 518-7700 in order that any outstanding issues be resolved.

FEES

If there are any fees due and owing in respect to this amendment, the Examiner is authorized to charge such fees to deposit account number 50-1047.

Respectfully submitted,

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Serial No.: **10/099,888**

Version with markings to show changes made

In the specification:

[0018] Various examples of all-optical reconfigurable optical switches are disclosed in U.S. Patent Application Serial No. [[PH-01-00-01]] 09/571,833, which is hereby incorporated by reference in its entirety, and in particular FIGS. 2-4 of that reference. The switching elements disclosed therein can selectively direct any wavelength component from any input port to any output port, independent of the routing of the other wavelengths without the need for any electrical-to-optical conversion. Another all-optical reconfigurable optical switch that provides additional functionality is disclosed in U.S. Patent Application Serial No.[[PH-01-00-02]] 09/691,812, which is hereby incorporated by reference in its entirety. This reference discloses an optical switching element in which each and every wavelength component can be directed from any given port to any other port without constraint. More specifically, unlike most optical switches, this switch is not limited to providing connections between a subset of input ports and a subset of output ports, or vice versa. Rather, this switch can also provide a connection between two ports within the same subset (either input or output). While the present invention may employ any of the aforementioned reconfigurable optical switches, the optical switch disclosed in U.S. Patent Application Serial No. [[PH01-00-02]] 09/691,812 will serve as an exemplary reconfigurable optical switch, and accordingly, additional details concerning this switch will be presented below.

[0019] In FIG. 7, the reconfigurable optical switch 800 comprises an optically transparent substrate 808, a plurality of dielectric thin film filters 801, 802, 803, and 804, a plurality of collimating lens pairs [821_1 and 821_2, 822_1 and 822_2, 828_1 and 823_2, 824_1 and 824_2], 821, 822, 823, and 824, a plurality of tiltable mirrors 815, 816, 817, and 818 and a plurality of output ports 840_1, 840_2, … 840_n. A first filter array is composed of thin film filters 801 and 803 and a second filter array is composed of thin film filters 802 and 804. Individual ones of the collimating lens pairs 821-824 and tiltable mirrors 815-818 are associated with each of the thin

film filters. Each thin film filter, along with its associated collimating lens pair and tiltable mirror effectively forms a narrow band, free space switch, i.e. a switch that routes individual channels or wavelength components along different paths. The tiltable mirrors are micro mirrors such as the MEMS (microelectromechanical systems) mirrors. Alternatively, other mechanisms may be employed to control the position of the mirrors, such as piezoelectric actuators, for example.

[0020] In operation, a WDM optical signal composed of different wavelengths λ_1, λ_2, λ_3 and λ_4 is directed from the optical input port 812 to a collimator lens 814. The WDM signal traverses substrate 808 and is received by thin film filter 801. According to the characteristics of the thin film filter 801, the optical component with wavelength λ_1 is transmitted through the thin film filter 801, while the other wavelength components are reflected and directed to thin film filter 802 via substrate 808. The wavelength component λ_1, which is transmitted through the thin film filter 801, is converged by the collimating lens [821_1] <u>821</u> onto the tiltable mirror 815. Tiltable mirror 815 is positioned so that wavelength component λ_1 is reflected from the mirror to a selected one of the output ports 840_1-840_n via thin film filters 802-804, which all reflect wavelength component λ_1. The particular output port that is selected to receive the wavelength component will determine the particular orientation of the mirror 815.

[0021] As mentioned, the remaining wavelength components λ_2, λ_3, and λ_4 are reflected by thin film filter 801 through lens [821_2] <u>821</u> back into substrate 808 and directed to thin film filter 802. Wavelength component λ_2 is transmitted through thin film filter 802 and lens [822_1] <u>822</u> and directed to a selected output port by tiltable mirror 816 via thin film filters 803-804, which all reflect wavelength component λ_2. Similarly, all other wavelength components are separated in sequence by the thin film filters 803-804 and subsequently directed by tiltable mirrors 817-818 to selected output ports. By appropriate actuation of the tiltable mirrors, each wavelength component can be directed to an output port that is selected independently of all other wavelength components.

[0026] An arrangement of reconfigurable optical switches such as depicted in FIG. 4

is employed in copending U.S. Patent Appl. Serial No. [[PH01-00-04C]] 10/099,890 to provide a protection scheme in the event of a transponder (i.e., a transmitter/receiver pair in which an optical signal originates as, or terminates in, an electrical signal) failure. This arrangement is shown in FIG. 5, which employs four switches 514, 516, 518 and 520. In comparing FIGS. 4 and 5 it should be noted while FIG. 4 only depicts a single fiber path 710 transmitting in one direction, in FIG.5 two fibers paths 530 and 540 are shown to support bi-directional communication (i.e., fiber path 710 in FIG. 4 corresponds to either of the fiber paths 530 and 540 in FIG. 5). In the configuration of FIG. 5 service can be maintained even if there is a failure in one of the switches. The transponders are arranged in transponder pairs 522-527 located in adjacent slots. The individual transponders in each pair can serve as backup for the other in case of a failure. The transponders in each pair communicate with different switches. For example, in pair 522, transponder 522_1 receives and transmits via switches 514 and 516, respectively, while transponder 522_2 receives and transmits via switches 520 and 518, respectively. Since the two transponders in each pair transmit and receive on completely different switches, a failure in one switch need not disrupt service because the service provided by the impacted switch can be provided by the other transponder in the adjacent slot. A comparison of FIGS. 4 and 5 suggests that any one or more of the transponder pairs 522-527 in FIG. 5 may be replaced with a subtending ring such as rings 712 and 714 in FIG. 4.